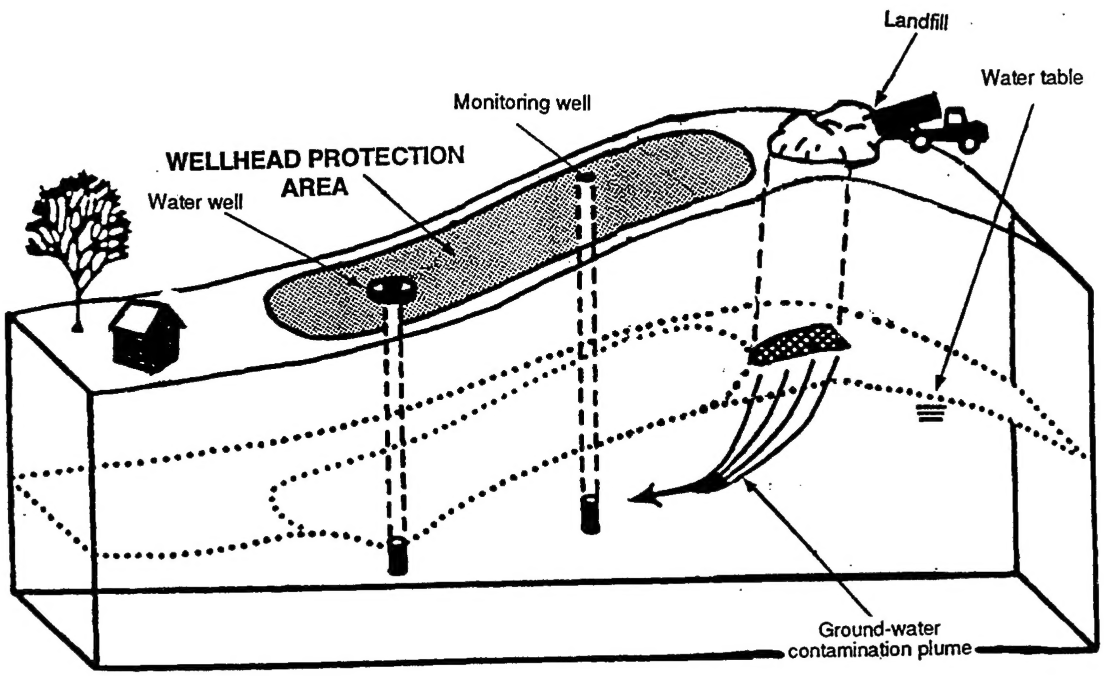
USACHPPM

Meeting The Requirements of the Wellhead Protection Program

(USACHPPM TECHNICAL GUIDE NO. 216)



U.S. Army Center for Health Promotion and Preventive Medicine

Readiness Thru Health

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) lineage can be traced back over a half century to the Army Industrial Hygiene Laboratory which was established at the beginning of World War II under the direct jurisdiction of The Army Surgeon General. It was originally located at the Johns Hopkins School of Hygiene and Public Health with a staff of three and an annual budget not to exceed three thousand dollars. Its mission was to conduct occupational health surveys of Army-operated industrial plants, arsenals, and depots. These surveys were aimed at identifying and eliminating occupational health hazards within the Department of Defense's (DOD) industrial production base and proved to be extremely beneficial to the Nation's war effort.

Most recently, the organization has been nationally and internationally known as the U.S. Army Environmental Hygiene Agency (AEHA) and is located on the Edgewood area of Aberdeen Proving Ground, Maryland. Its mission had been expanded to support the worldwide preventive medicine programs of the Army, DOD and other Federal agencies through consultations, supportive services, investigations and training.

On 1 August 1994, the organization was officially redesignated the U.S. Army Center for Health Promotion and Preventive Medicine and is affectionately referred to as the CHPPM. As always, our mission focus is centered upon the Army Imperatives to that we are optimizing soldier effectiveness by minimizing health risk. The CHPPM's mission is to provide worldwide scientific expertise and services in the areas of:

- Clinical and field preventive medicine
- Environmental and occupational health
- Health promotion and wellness
- Epidemiology and disease surveillance
- Related laboratory services

The Center's quest has always been one of customer satisfaction, technical excellence and continuous quality improvement. Our vision is to be a world-class center of excellence for enhancing military readiness by integrating health promotion and preventive medicine into America's Army. To achieve that end, CHPPM holds everfast to its core values which are steeped in our rich heritage:

- Integrity is our foundation
- Excellence is our standard
- Customer satisfaction is our focus
- Our people are our most valuable resource
- Continuous quality improvement is our pathway

Once again, the organization stands on the threshold of even greater challenges and responsibilities. The CHPPM structure has been reengineered to include General Officer leadership in order to support the Army of the future. The professional disciplines represented at the Center have been expanded to include a wide array of medical, scientific, engineering, and administrative support personnel.

As the CHPPM moves into the next century, we are an organization fiercely proud of our history, yet equally excited about the future. The Center is destined to continue its development as a world-class organization with expanded preventive health care services provided to the Army, DOD, other Federal agencies, the Nation, and the world community.

MEETING THE REQUIREMENTS OF THE WELLHEAD PROTECTION PROGRAM
(USACHPPM TECHNICAL GUIDE NO. 216)

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MEETING THE REQUIREMENTS OF THE WELLHEAD PROTECTION PROGRAM

(USACHPPM TECHNICAL GUIDE NO. 216)

CHAPTER 1
INTRODUCTION

1-1. Purpose

The purpose of this technical guide (TG) is to provide U.S. Army installations with basic guidance on the steps required to address the Wellhead Protection (WHP) Program established in the Safe Drinking Water Act (SDWA) Amendments of 1986.

1-2. Scope

This TG applies to installations which have ground water as a source of drinking water. Installations that depend solely upon surface water or that purchase water from another Public Water Supply (PWS) may be affected by a neighboring system's WHP plan if a portion of the installation is included in that system's Wellhead Protection Area (WHPA). This TG supplies good information as a first resource when addressing the WHP Program. A more detailed documentation of specific State program requirements, including a list of Army installations affected by State WHP programs is included in a recent document produced for the U.S. Army Environmental Center entitled Final Wellhead Protection Requirements and the Status of Army Facilities, by Horne Engineering Services, Inc., April 1995. Copies of the document can be obtained by contacting the U.S. Army Environmental Hotline at 1-800-USA-3845.

1-3. References

Appendix A contains a list of relevant references pertaining to the WHP program, development of a WHP plan, methods of WHPA delineation, and the impact of the WHP program on U.S. Army installations.

1-4. Abbreviations and Terms

The glossary contains the abbreviations and definitions of key terms used in this TG.

1-5. Further Assistance

Additional assistance regarding topics discussed in this TG may be obtained from the Water Supply Management Program of the USACHPPM at DSN 584-3919 or commercial (410) 671-3919 or the U.S. Army Environmental Hotline at 1-800-USA-3845.

CHAPTER 2
THE WELLHEAD PROTECTION PROGRAM

2-1. Regulatory Background

The SDWA Amendments of 1986 established the WHP Program in an effort to protect the recharge area of PWS wells from all sources of contamination. This regulatory relationship is discussed in USACHPPM TG 179, Guidance for Providing Safe Drinking Water at Army Installations, which details requirements of the SDWA. States were given the responsibility of developing their own individual WHP programs which, upon being approved by the U.S. Environmental Protection Agency (EPA), were to be implemented starting in 1991. As of the end of 1995, there were 41 States and territories with EPA approved WHP programs. They are listed in Appendix C. The EPA has put out guidance to the States on how to develop individual State WHP programs. The Federal program did not require that the States create a mandatory program and, therefore, WHP is voluntary in many States. Many States have passed the burden of developing a program down to the municipality and PWS level. For these reasons no two WHP programs will be exactly alike, and negotiation of terms will be a very important aspect in determining how each installation will meet its respective State requirements.

2-2. Program Contents

A WHP program requires or encourages systems using ground water as a source of drinking water to properly manage the land surface around a well or well field where activities might result in contamination of the ground water drawn by the well. In order to provide such management, systems should develop a WHP plan. This plan regulates activities within a drinking water well's or well field's WHPA in order to prevent contamination from reaching the well or well field. The steps involved in developing a plan are: (1) delineating a WHPA, (2) inventorying all of the potential sources of contamination to the well or well field located within the WHPA, (3) developing a management plan to protect the well or well field from those sources, and (4) creating a contingency plan to provide drinking water to the supplied population in the event that the well or well field does become contaminated.

2-3. Initial Actions

Installations should first get a copy of their State's WHP program and determine what aspects of the program apply. If the State has no EPA approved program, then installations should

consult the State's ground-water management personnel to determine what other ground-water or WHP activities or regulations may apply.

2-4. Key Individuals

The WHPAs established in the development of an installation's WHP plan may encompass the areas of operation for many different organizations on the installation. The WHPA may even encompass land owned by neighboring towns and cities. In such cases, it may be necessary to solicit the cooperation of the governing personnel of these entities. Development of the WHP plan should be a team effort, with input from all organizations affected. Potential WHP team members include:

a. Commander
b. Directorate of Public Works
c. Directorate of Safety, Health, and Environment
d. Directorate of Engineering and Housing
e. Directorate of Logistics
f. MEDDACs and MEDCENs
g. Hazardous waste generating activities
h. Installation Preventive Medicine
i. Installation Safety Officer
j. Defense Reutilization and Marketing Office
k. Tenant activities
l. Local government leaders
m. State and local drinking water agencies.

2-5. Interpreting the State's Program

Once the members are assembled, the WHP team must define the installation's goals and the steps necessary to reach them. Goals cannot be set without carefully interpreting how the State's WHP program applies to the installation's operations. Taking extra time to fully understand what the State's WHP program will require of the installation may save time and resources wasted on unnecessary actions.

CHAPTER 3
CHARACTERIZATION OF AN AQUIFER

3-1. General

Geology and hydrology vary tremendously from region to region, from State to State, and even between neighboring towns. Because of this huge geologic variability, no single "generic" WHP plan would suffice in protecting all wells or well fields. Before a WHP plan can be developed and implemented, there are some basic questions that need to be answered pertaining to the ground water and the aquifer in which it is stored. Each State will have its own criteria for delineating a WHPA which will affect the amount of aquifer information needed. Some of the aquifer specific information that may be necessary for compliance with the State's program is:

a. Well locations
b. Pumping rates
c. Depth to aquifer
d. Thickness of aquifer
e. Net recharge for the aquifer
f. Drawdown around pumping well
g. Soil types overlying aquifer (Vadose Zone)
h. Topography around wellhead
i. Lithology of the aquifer
j. Degree of confinement of the aquifer
k. Storativity of the aquifer
l. Transmissivity of aquifer
m. Hydraulic conductivity of the aquifer
n. Ground-water flow direction(s)
o. Ground-water flow velocity
p. Ground-water divide locations.

3-2. Information Sources

Potential sources for the above information include:

a. United States Geological Survey (USGS)
b. U.S. Army Corps of Engineers (USACE)
c. United States Department of Agriculture (USDA)

d. Well drillers' logs
e. USAEHA* Environmental Operation Summary Documents
f. U.S. Army Environmental Center (USAEC)
g. Geology departments of local or State universities
h. Local and State health departments
i. Local and State regulatory agencies.

3-3. Data Collection

Some State WHP programs may require information and aquifer criteria that have not been collected for the installation's aquifer. If this is the case, the hydrogeologic data will have to be collected before further progress can be made in delineating the WHPA. While some installations may have the personnel and resources to gather hydrogeologic criteria, most will need to contract out for such services.

* The U.S. Army Environmental Hygiene Agency, now called the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM).

CHAPTER 4
DELINEATION OF THE WELLHEAD PROTECTION AREA

4-1. Wellhead Protection Area Terminology

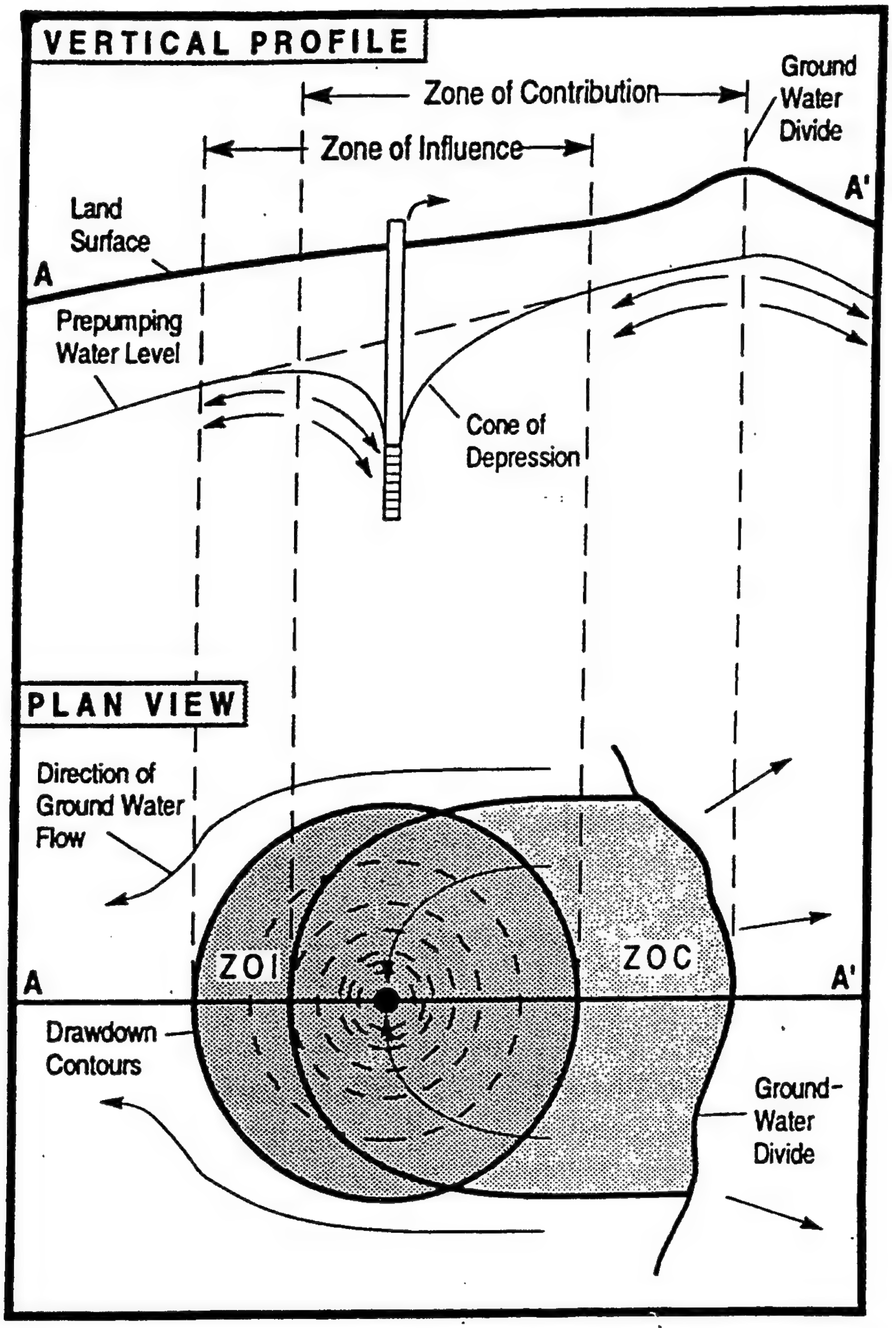
A Zone of Contribution (ZOC) defines the geographic limits in which water "recharges" the aquifer from which drinking water is extracted (see Figure 1). These zones are not fixed, and may change their shape and size depending upon pumping rates and other factors that affect ground water. The SDWA defines a WHPA as "the surface and subsurface area surrounding a water well or well field, supplying a PWS, through which contaminants are ***reasonably*** likely to move toward and reach such water well or well field." Obviously, the most protective WHPA would encompass the entire ZOC of a well or well field given its most strenuous pumping scenario. Delineation of such an area is not always reasonable or possible. The EPA has promulgated guidance to the States on various criteria and methods used to achieve a WHPA that properly encompasses a ***reasonably*** protective portion of the ZOC. The interpretation of ***reasonably*** will vary from State to State and, therefore, so will the acceptable methods used to delineate a WHPA. Some States may require a very detailed analysis resulting in a very representative and all-encompassing WHPA, while other States may accept a generic radius-sized WHPA.

4-2. Base Maps

The WHPA must be a mappable area that can be plotted on a "base map." Base maps must display the natural features of the installation, both surface and subsurface, and show the location of supply wells. Overlays will be added to the base map that depict drainage areas, wetlands, floodplains, ground-water resources, land-use zones, and eventually, the WHPA and all potential sources of contamination. Types of maps that are useful in delineating a WHPA are:

a. Topographic
b. Geologic
c. Soils
d. Aerial photos
e. USGS hydrologic atlas
f. Well logs
g. Water table maps
h. Land use maps.

Figure 1. WHPA Associated Terminology Prepared by Horsley and Witten, Inc.
(Source: Seminar Publication--Wellhead Protection: A Guide for Small Communities, EPA 625/R-93/002, February 1993.)



4-3. Delineation Criteria

There are five criteria that a State can require the delineation of a WHPA to be based upon. All of the delineation methods (discussed in paragraph 4-4) are based upon one or more of these criteria:

a. Distance - a radius or dimension of a specified distance measured outward from the pumping well. Distance is the most basic, and often least accurate, criterion used in delineating a WHPA. The distance criterion is often used as an initial phase until a more thorough delineation method is completed.

b. Drawdown - the lowering of the water table surrounding a well during pumping (cone of depression) (see Figure 1). Drawdown is greatest at the well and decreases with distance from the well. At some point, the ground water is not affected by the pumping well. This outer limit is considered the edge of the Zone of Influence (ZOI). When drawdown is used, the ZOI may become the WHPA.

c. Time of Travel (TOT) - the amount of time necessary for ground water or a contaminant to travel from point X to the pumping well. WHP plans may be based upon protection of the well for a given amount of time (e.g., 10 years). The WHPA boundaries (point X) would then be back calculated based upon a 10-year TOT.

d. Flow Boundaries - ground-water divides and other physical/hydrologic features such as impermeable soil layers and bodies of surface water that influence and control ground-water flow. The area defined by these features is called the ZOC and may be used as the WHPA. This criteria is the most protective, assuming that contamination occurring anywhere within the ZOC will eventually reach and contaminate the well.

e. Assimilative Capacity - an aquifer's "natural" ability to attenuate or dilute the concentration of a contaminant. This criterion reduces the area of the ZOC included in the WHPA by assuming that if contamination occurred within the outer portions of the ZOC, it would be diluted to an acceptable level by the time it reached the pumping well. Caution should be used when applying this criterion because acceptable data has been acquired for only a limited number of contaminants.

4-4. Delineation Methods

The EPA has outlined six methods that the States may use to translate criteria into mappable boundaries. The States will weigh the inherent strengths and weaknesses of each method in deciding which to accept in their WHP program. The following are the six primary methods, listed in order of increasing technical sophistication and cost, both in money and time:

a. Arbitrary Fixed Radius. A circle with a specified radius is delineated around the pumping well. Semianalytical criteria are used to specify the radius of the circle, such as the approximated average TOT for a contaminant under conditions similar to those of the local aquifer. The simplicity of this method may result in a WHPA that is not representative of the actual ground-water flow within the aquifer. Under- or over-protection may result. Figure 2 depicts a typical WHPA delineated using the arbitrary fixed radius method.

b. Calculated Fixed Radius. The calculated fixed radius also defines a circle around the pumping well as the WHPA. The radius of the circle is calculated based on the volume of water that will move toward the pumping well in a specified amount of time. The chosen time is an estimate of the time needed to clean up ground-water contamination before it reaches the well. This method requires more specific knowledge of the well's pumping rate and the porosity and hydraulic conductivity of the local aquifer. Figure 3 depicts the simple concept of a WHPA delineated using a calculated fixed radius. Figure 4 depicts a WHPA delineation using a volumetric flow equation to calculate the fixed radius.

c. Simplified Variable Shapes. States may have a library of standardized WHPA delineation shapes that they have created based upon the various hydrologic conditions that occur within the State. Using parameters of the aquifer such as porosity, flow direction, and pumping rate, these preformed shapes can be incorporated into any WHP plan with relatively little expense in time and money. Figure 5 depicts several simplified variable shapes that can be used to delineate a well's WHPA.

d. Analytical Methods. Uniform flow equations are used to derive a profile of the ground-water flow and contaminant transport within the aquifer. The variables of these equations are site-specific parameters such as conductivity, hydraulic gradient, porosity, transmissivity, and aquifer thickness. Computer software programs are available that can generate a WHPA profile given the appropriate input. Figure 6 shows a WHPA delineated by using a uniform flow equation.

e. Hydrogeologic Mapping. Geologic, geophysical, and dye tracing methods are used to determine ground-water flow boundaries, which in turn are used to delineate the WHPA. This process requires lithologic and permeability changes within the aquifer to be detected and mapped by experienced hydrogeologists. Figure 7 contains a WHPA delineated by a hydrogeologic method.

Figure 2. WHPA Delineation Using the Arbitrary Fixed Radius Method.
(Source: Guidelines for Delineation of Wellhead Protection Areas, EPA 440/6-87-010, June 1987.)

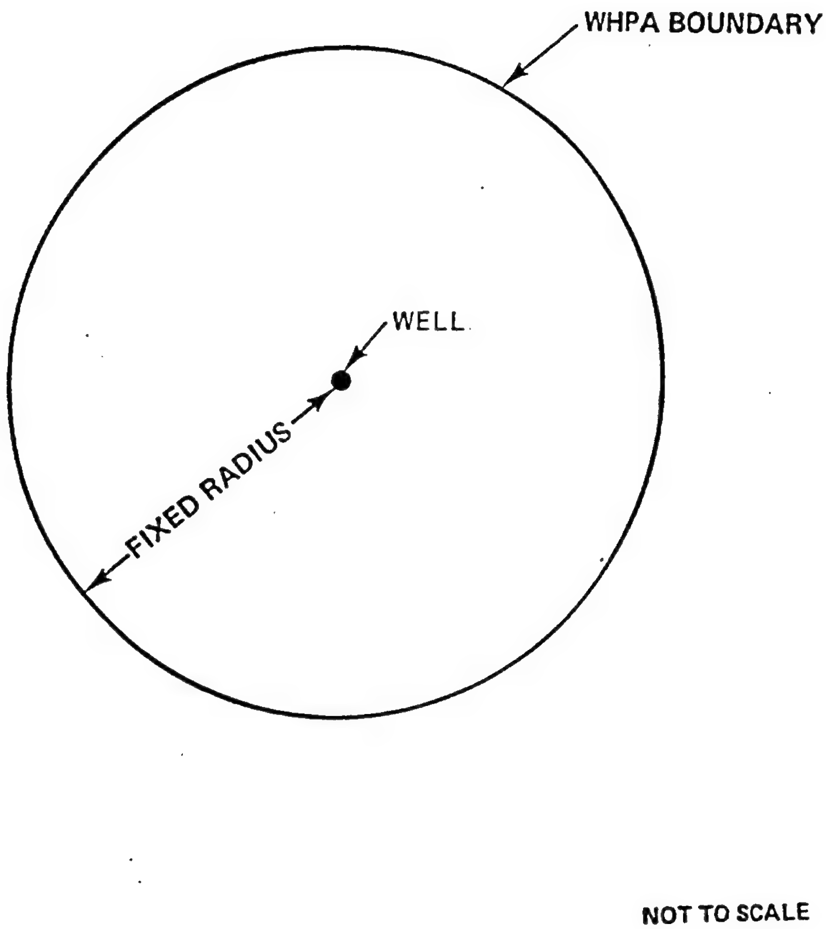
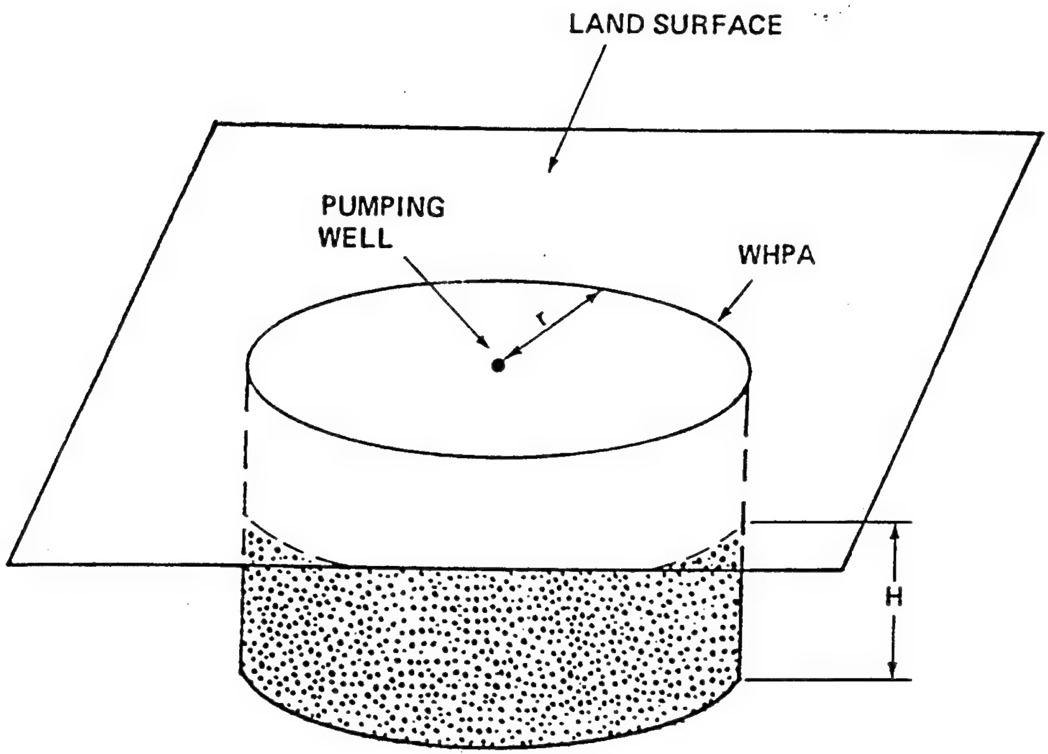


Figure 3. WHPA Delineation Using the Calculated Fixed Radius Method.
(Source: Guidelines for Delineation of Wellhead Protection Areas, EPA 440/6-87-010, June 1987.)



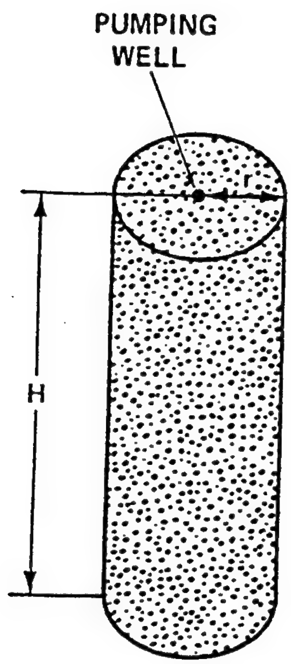
-Radius (r) is calculated using a simple equation that incorporates well pumping rate and basic hydrogeologic parameters.

-Radius determines a volume of water that would be pumped from well in a specified time period.

H = Open interval or length of well screen.

NOT TO SCALE

Figure 4. Volumetric Flow Equation to Calculate Fixed Radius for WHPA.
(Source: Guidelines for Delineation of Wellhead Protection Areas, EPA 440/6-87-010, June 1987.)



$$r = \sqrt{\frac{Q\,t}{\pi\,n\,H}} = 1138 \text{ ft}$$

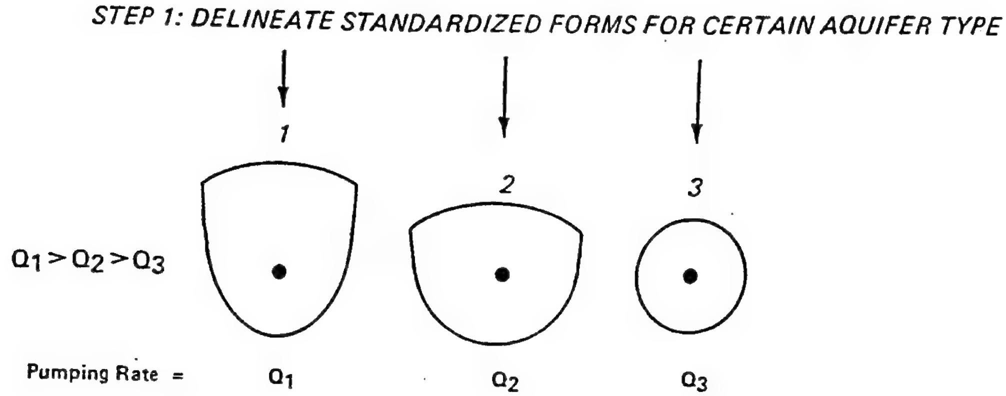
WHERE
Q = Pumping Rate of Well = 694.4 gpm = 48,793,668 ft^3/yr
n = Aquifer Porosity = 0.2
H = Open Interval or Length of Well Screen = 300 ft
t = Travel Time to Well (5 Years)

(Any consistent system of units may be used.)

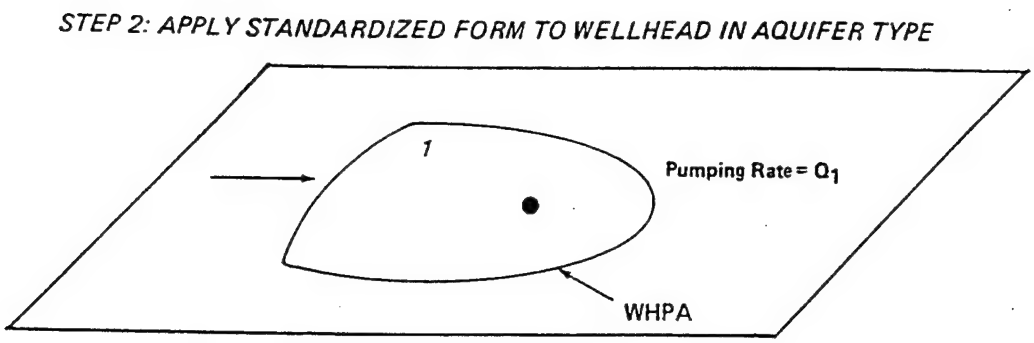
$$\underbrace{Q\,t}_{\text{VOLUME PUMPED}} = \underbrace{n\,\pi\,H\,r^2}_{\text{VOLUME OF CYLINDER}}$$

NOT TO SCALE

Figure 5. WHPA Delineation Using Simplified Variable Shapes Method.
(Source: Guidelines for Delineation of Wellhead Protection Areas, EPA 440/6-87-010, June 1987.)



-Various standardized forms are generated using analytical equations using sets of representative hydrogeologic parameters.
-Upgradient extent of WHPA is calculated with TOT equation; downgradient with uniform flow equation.

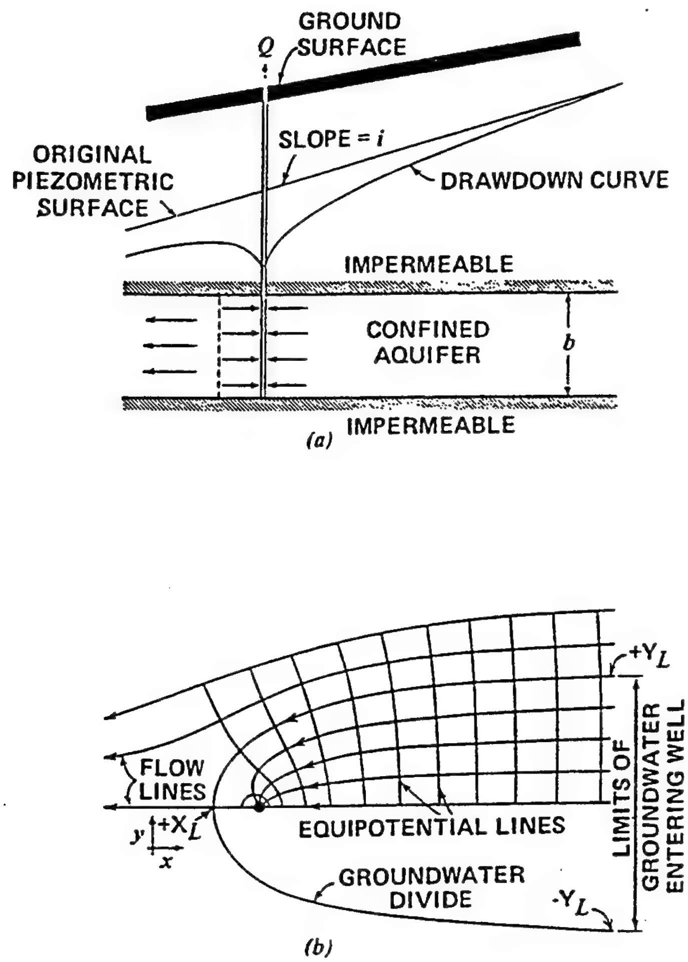


-Standardized form is then applied to well with similar pumping rate and hydrogeologic parameters.

LEGEND:
- Pumping Well
- Direction of Ground-Water Flow

NOT TO SCALE

Figure 6. WHPA Delineation Using the Uniform Flow Analytical Model.
(Source: Guidelines for Delineation of Wellhead Protection Areas, EPA 440/6-87-010, June 1987.)



$$-\frac{Y}{X} = \tan\left(\frac{2\pi Kbi}{Q} Y\right)$$

UNIFORM-FLOW EQUATION

$$X_L = -\frac{Q}{2\pi Kbi}$$

DISTANCE TO DOWN-GRADIENT NULL POINT

$$Y_L = \pm \frac{Q}{2Kbi}$$

BOUNDARY LIMIT

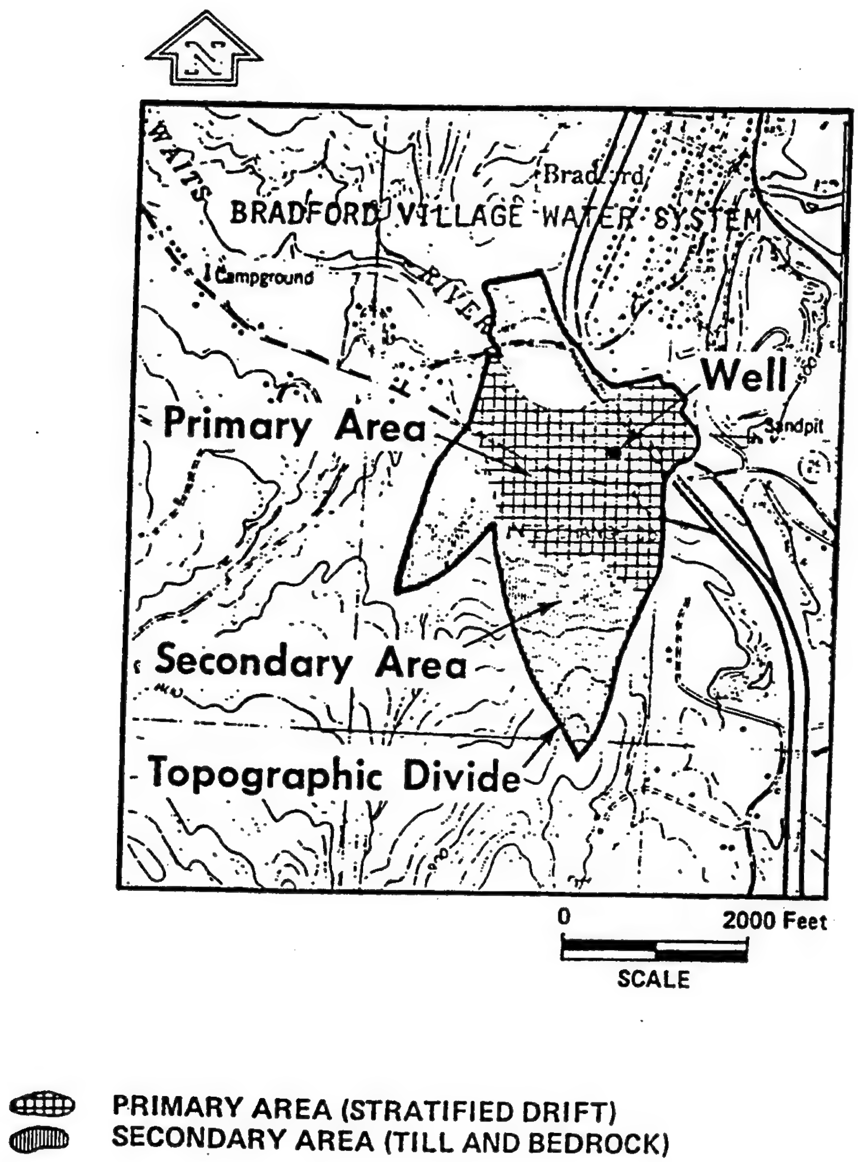
LEGEND:

● Pumping Well

Where:
Q = Well Pumping Rate
K = Hydraulic Conductivity
b = Saturated Thickness
i = Hydraulic Gradient
π = 3.1416

NOT TO SCALE

Figure 7. WHPA Delineation Using Hydrogeologic Mapping, An Example from Vermont.
(Source: Guidelines for Delineation of Wellhead Protection Areas, EPA 440/6-87-010, June 1987.)



f. Numerical Flow/Transport Models. Computer models are used that numerically approximate the ground-water flow and contaminant transport equations. These models can handle a greater number of variables than the analytical method, and tend to give a more "realistic" picture of what forces are at work within a complex aquifer. Tremendous amounts of site-specific and contaminant-specific data are required for this procedure that may make the numerical models impracticable for some WHP plans.

4-5. Delineation Requirements

From the above, it is obvious that delineation of a WHPA can span a continuum from the simplistic (in the case of an arbitrary fixed distance) to the technically complex (in the case of using computer models that require esoteric data and hydrogeologic specialists). If not specifically defined in the State's WHP program, negotiations with the State's WHP agencies will determine the criteria and methodology that allow compliance by individual installations. A Memorandum of Understanding (MOU) should be created that outlines the requirements of the installation regarding delineation of its WHPA. The table below compares the relative costs of delineation using the various methods described above. Remember that the most simplistic methods may result in an extremely conservative WHPA that increases the operating costs of an unnecessarily large number of facilities.

Table. Cost Comparison of Various WHPA Delineation Methods.
(Source: Seminar Publication--Wellhead Protection: A Guide for Small Communities, EPA 625/R-93/002, February 1993.)

Method	Person-hours Required per Well	Level of Expertise*	Cost per Well	Potential Overhead Costs
Arbitrary Fixed Radius	1-5	1	$12-60	Low
Calculated Fixed Radius	1-10	2	$17-170	Low
Simplified Variable Shapes	1-10	2	$17-170	Low to Med.
Analytical Methods	2-20	3	$60-600	Medium
Hydrogeologic Mapping	4-40	3	$120-1,200	Med.-High
Numerical Modeling	10-200+	4	$350-7,000+	High

* Hourly wages (in 1993 dollars) per level of expertise assumed to be:

1. Nontechnical $12
2. Junior Hydrogeologist/Geologist $17
3. Mid-Level Hydrogeologist/Modeler $30
4. Senior Hydrogeologist/Modeler $35

Potential overhead costs include those for equipment to collect hydrogeologic data, computer hardware and software, and the costs associated with report preparation. These figures do not reflect the costs for consulting firms potentially engaged in this work.

CHAPTER 5
INVENTORY OF SOURCES OF WELLHEAD CONTAMINATION

5-1. General

Once a WHPA has been delineated, all possible sources of wellhead contamination lying within the WHPA will need to be inventoried. A Wellhead Contamination Source Inventory includes the identification, characterization, and prioritization of the various sources and the risk they pose to the wellhead. These sources will eventually be plotted on the base map containing the WHPA.

5-2. Sources of Concern

Figure 8 portrays some typical threats of contamination to the ground water. The EPA document Guide For Conducting Contaminant Source Inventories For Public Drinking Water Supplies, EPA Document Number 570/9-91/014, December 1991, presents the following breakdown of potential sources of wellhead contamination:

a. Sources Designed to Discharge Substances - to include home septic tanks, cesspools, injection wells, and land application of sludge and wastewater.

b. Storage, Treatment, and Disposal Sources - to include landfills, open dumps, surface impoundments, waste tailings and piles, material stockpiles, animal burial, above and underground storage tanks, open burning sites, detonation sites, and radioactive disposal sites.

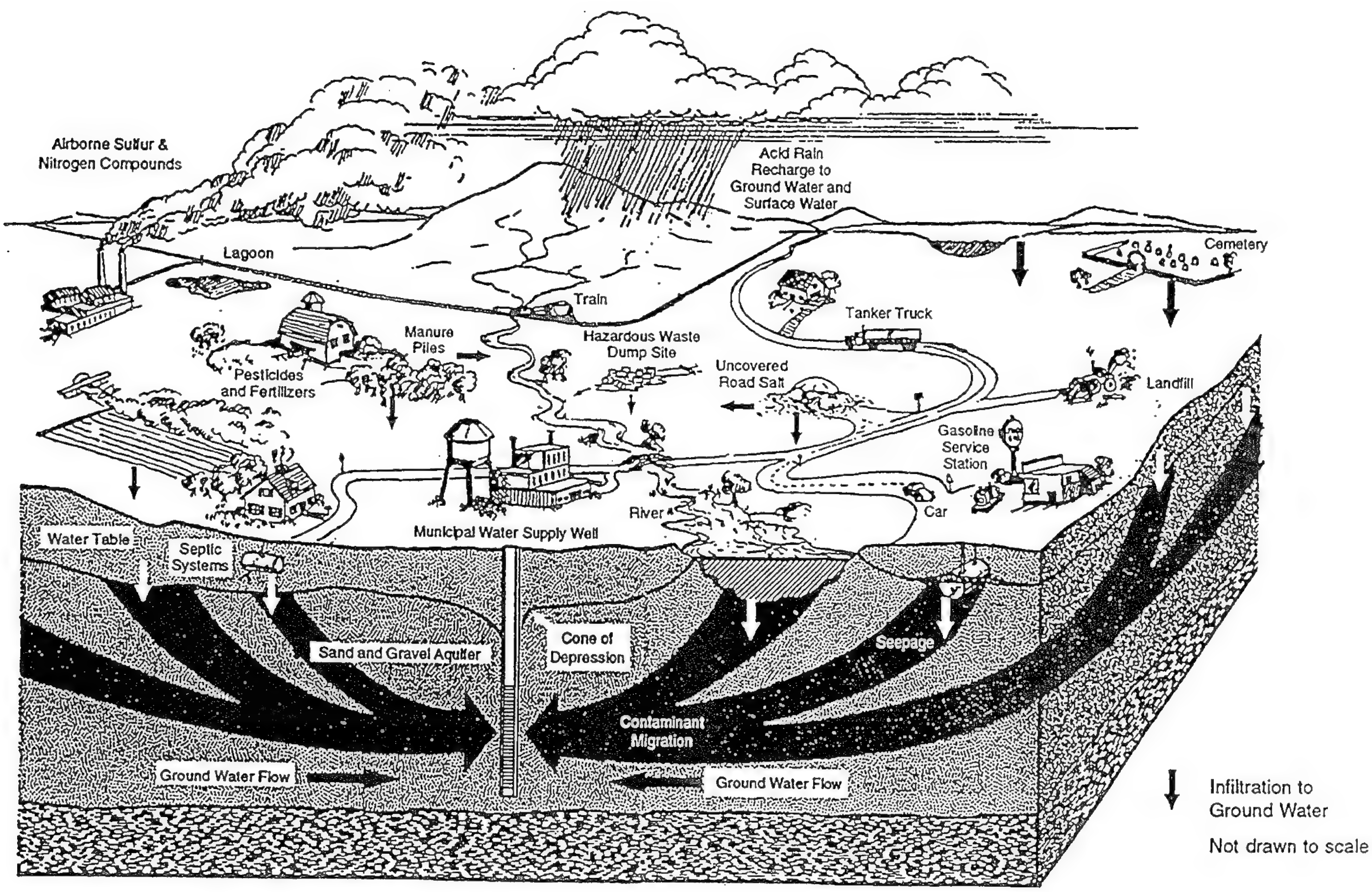
c. Transportation Sources - to include pipelines and transport and transfer operations of both hazardous and nonhazardous wastes and nonwastes.

d. Runoff Sources - to include applications of pesticides, fertilizers, de-icing salts, animal feed operations, storm water runoff, and construction runoff.

e. Direct Routes into Aquifer - to include production wells, exploration wells, monitoring wells, and construction excavations.

f. Natural Sources Contaminated by Human Activity - to include surface waters and natural leaching processes.

Figure 8. Examples of Potential Sources of Contamination to the Ground Water.
(Source: Seminar Publication--Wellhead Protection: A Guide for Small Communities, EPA 625/R-93/002, February 93.)



5-3. Methods of Source Identification

Common methods of obtaining the information include accessing existing data sources, surveys, and site visits.

a. Existing Data Sources. There are multiple sources of information on potential sources of wellhead contamination that can be used and will greatly decrease the cost of developing an inventory. Several environmental regulations require State and local regulatory agencies to maintain databases on various potentially contaminating activities within their jurisdiction. Some of the regulations that require certain information to be maintained include:

(1) Resource Conservation and Recovery Act (RCRA) Subtitle C requires notifications from generators of >100 Kg/month of hazardous waste, and the permitting of treatment, storage, disposal facilities.

(2) RCRA Subtitle I requires notification documents from owners and operators of underground storage tanks.

(3) Superfund Amendments and Reauthorization Act (SARA) Title III requires facilities to prepare a list of "extremely hazardous" substances on hand in amounts >2 lbs. Releases of certain substances must also be reported under Title III.

(4) The Underground Injection Control Program of the SDWA requires a permit for any injection well operations.

(5) The National Pollution Discharge Elimination System (NPDES) requires permits for any discharge into navigable surface waters.

(6) Spill Prevention Control and Countermeasure (SPCC) plans must be prepared by facilities that store bulk quantities of petroleum (i.e., a total of >42,000 gallons stored underground or >1,320 gallons above ground or a single tank of >660 gallons capacity).

Databases containing the above information are available through the EPA offices and State and local agencies. Information on the location of facilities is contained in these databases which can be useful in determining which facilities lie within a WHPA.

b. Surveys. Various types of surveys can be useful tools in identifying potential sources of contamination that may not be registered on regulatory databases. Surveys can be carried out through the mail or over telephone lines. Typical survey questions ask for information on the types of chemicals stored and used at a facility, previous site uses, and the time span of operations.

c. Site Visits. There is no substitute for getting out and walking or driving through the WHPA to look at the various facilities which may pose a threat of contamination to the ground water. These visits may be combined with survey methods as a kind of quality control step to verify the answers of various facility respondents.

5-4. Prioritization of Potential Contaminants

After the inventory of potential wellhead contamination sources has been compiled, a risk assessment of each source must be accomplished in terms of the likelihood of a release, the likelihood that such a release will reach the well, the toxicity of potential contaminants, the amount of contaminant that could potentially be released, and the potential attenuation (dilution) of various substances prior to reaching a well. Such a risk assessment will require both contaminant and site specific information. Contaminant source parameters could include:

a. Type of chemical sources on hand, to include mixtures
b. Amounts of potential contaminants used/stored at site
c. Age of facilities/equipment used in handling contaminant
d. Description of site operations
e. Safety precautions/programs executed at the facility
f. Toxicity, mobility, and persistence of chemicals.

Sources of information for these parameters at each facility include:

a. Material Safety Data Sheets (MSDS)
b. Integrated Risk Information System (IRIS)
c. RCRA and other reports that are mandatory for hazardous material generators and users.

The potential sources of contamination should be prioritized according to the level of risk that they present, creating a priority scheme for management of the sources. The EPA document Managing Ground-Water Contamination Sources in Wellhead Protection Areas: A Priority Setting Approach, EPA 570/9-91-023, October 1991, offers environmental managers a simplified risk assessment system that uses limited data to derive an assessment of potential

sources of contamination. This priority setting approach was designed for wellheads located in areas with homogenous and isotropic hydrogeology, but the systematic approach outlined in the manual makes it a valuable guide to any installation.

CHAPTER 6
WELLHEAD PROTECTION MANAGEMENT

6-1. Wellhead Protection Management Techniques

The most important aspect of the WHP plan is the management scheme to control future land use and to regulate present potential contamination sources within the WHPA. Without an effective ongoing management process, any WHP plan will become fragmented and ineffective. There are many different WHP management techniques. A few examples are listed below that could be easily implemented by an Army installation.

a. Land Use Planning. The Department of the Army requires that all installations base their physical development on a master plan. Most installations were built in a pre-environmentally conscious era. Often their missions have undergone considerable change that further complicates any land-use planning. These real-world influences make land-use planning all the more important for installations to operate effectively in these environmentally stringent times. All new development projects should be scrutinized in terms of how they may impact any existing and potentially new sources of drinking water. Restricting the types of operations and facilities that can occur within the WHPA will reduce future problems with State officials and the public.

b. Design Standards. Design standards typically are applied to new buildings, structures, and road/parking lot runoff collection systems. Design standards will require technical expertise to create and they need to be specific enough to allow consistent evaluation of a development project. Words such as "adequate," "sufficient," and "regular" need to be quantified to reduce the ambiguity involved with compliance.

c. Operating Standards. Operating standards can greatly aid in the control of potential wellhead-contaminating operations and practices. Practices such as application of pesticides, fertilizers, and herbicides; road-salting; and construction within the WHPA should be strictly governed. The language used in operation protocols needs to be specific and easily interpreted by all involved.

d. Site Plan Review. Once design and operating standards are established, a procedure for the review of site plans and intended operations must be included to ensure adherence to the standards. Such reviews require trained personnel and time to accomplish and should be planned for in the development of any project on the installation.

e. Ground-Water Monitoring. Ground-water monitoring wells may be the front-line defense against wellhead contamination. Such a monitoring system will give early warning to potential contamination as well as some idea of where the contaminants are originating. Remember that monitoring wells can become a source of contamination themselves, and their installation and operation should be included in the design and operating standards in the WHP plan.

f. Water Conservation. Water conservation can reduce the drawdown or the ZOI, which in turn may reduce the potential for wellhead contamination. If the WHPA delineation method uses drawdown or TOT, reducing the amount of water pumped from the aquifer may reduce the size of the WHPA and cause fewer potentially contaminating facilities to fall within the WHPA.

g. Pollution Prevention Through Process Changes. Pollution prevention at the source is the most effective management technique for reducing the potential threat of wellhead contamination. Process change can take the form of increased passive and active confinement structures/operations when dealing with hazardous substances, the substitution of less toxic substances into industrial and domestic processes, and the elimination of unnecessary practices within the WHPA.

h. Public Education. Educating the public and employees on the vulnerability of ground water and the importance of its protection to public health will build support for regulatory programs such as the WHP Program. Newsletters, brochures, voluntary committees, videos, press conferences, and public speakers can all inform the public on the installation's commitment to the welfare of the surrounding community.

6-2. Geographical Information Systems

Geographical Information Systems (GISs) could be considered an aspect of all of these management techniques and is mentioned here to emphasize this growing field of land-use management. A GIS is a computer database that incorporates various land attributes and land uses to create map overlays of the installation. Layers of information can be superimposed over a graphical representation of an area that depicts a WHPA, ground-water flow, location of production and monitoring wells and all potential sources of wellhead contamination. These systems are not cheap, nor "user-friendly" at this time, but a GIS can greatly reduce the amount of abstract visualization that is required whenever humans attempt to comprehend complex environmental systems. Their use may prove very valuable in the development of a WHP plan.

CHAPTER 7
WELLHEAD PROTECTION CONTINGENCY PLANS

7-1. General

The last portion of all WHP plans is a contingency plan identifying alternative sources of drinking water to be used in the event of wellhead contamination. Appendix A lists several references pertaining to the development of a realistic and implementable contingency plan.

7-2. Alternative Sources of Potable Water

In the event of wellhead contamination, the number one priority of the installation must be to reestablish access of potable water to its population. Due to the complexities and difficulties involved with ground-water remediation, both short-term and long-term alternative sources of drinking water need to be considered in the WHP contingency plan.

a. Short-term Replacement Options:

(1) Bottled water. Bottled water is often readily available from retail stores or bottling facilities. Bottled water is generally well received by consumers. All bottled water used should meet current SDWA National Primary Drinking Water Regulations for contaminant limits. Drawbacks to using bottled water include high cost for transportation to remote areas, the potential for inadequate supply, and the inability to meet firefighting and industrial needs.

(2) Use of stored supplies. Stored supplies may meet the demands of the installation in the short term with minimal disruption of service. The quality of such stored water must be checked and protected. Stored water may meet installation needs until a longer term alternative source can be secured.

(3) Tank trucks. Most installations have various means to transport water--from the 400-gallon "water buffalo" to the 3000-gallon potable water-tankers. Always ensure that the vehicles used to transport water have never been used to transport materials toxic to human health.

(4) Point-of-entry and point-of-use treatment. Point-of entry (POE) and point-of-use (POU) treatment devices provide additional or alternative treatment of distributed drinking water at the point of the consumer. POE devices treat the water at the water's entry point to a building. POE devices may be used as a long-term treatment alternative with the State's

approval. POU devices are tap or location specific treatment devices, leaving water at other tap water locations in the building untreated. The most important consideration when choosing a POE/POU device is to choose the right device for the desired treatment. The National Sanitation Foundation (NSF) provides a certification program for POE/POU devices. Choosing the proper device from this approved list would ensure consumer safety. (NSF International, 3475 Plymouth Rd., P.O. Box 130140, Ann Arbor, MI 48113-0140.)

b. Long-term Replacement Options:

(1) Excess capacity. If the installation has several ground-water wells in operation, uncontaminated wells may be able to handle increased pumping to meet installation needs. This sort of contingency requires detailed knowledge of the hydrology of the aquifer(s). It is possible that pumping more water from other wells will change the path of the contaminants in the ground water to contaminate the uncontaminated wells.

(2) Surface water. Ground water may be the preferred source for the installation due to the extra treatment associated with the use of surface water. Available surface water assets may be used if the proper treatment facilities are available. Installations may have access to Reverse Osmosis Water Purification Units (ROWPUs) that would aid in the treatment of surface water.

(3) Interconnection with outside supply system. An installation may be able to connect with a nearby community PWS to meet its need until wellhead contamination is remedied. Such a plan requires extensive coordination with community authorities before any actual connection is made to the distribution system. This alternative may provide a permanent solution to water supply at the installation if the neighboring PWS can handle the demand.

(4) Drilling new wells. If the installation can access an uncontaminated upgradient portion of the aquifer or a separate aquifer, it may choose to abandon the contaminated well and develop new drinking water wells.

(5) Additional treatment with existing equipment. Some contaminants, such as bacteria or minerals, may be effectively treated by the existing treatment system. Such treatment may require an increased use of treatment chemical or increased filtration to ensure potable water.

(6) Additional treatment with new equipment. Contaminated water may be treated by the addition of one or more treatment steps to the existing treatment system. Typical steps include air stripping, addition of activated carbon, and biological treatment for organic contaminants and chemical precipitation for inorganic contaminants.

APPENDIX A
REFERENCES

GENERAL

USAEHA Information Paper No. 16: Sole Source Aquifers, USAEHA, 1 August 1983.

Seminar Publication--Protecting of Public Water Supplies from Ground-Water Contamination, EPA 625/4-85/016, September 1985.

Wellhead Protection Programs: Tools for Local Governments, EPA 440/6-89-002, April 1989.

Progress in Ground-Water Protection and Restoration, EPA 440/6-90-001, February 1990.

Wellhead Protection Strategies for Confined-Aquifer Settings, EPA 570/9-91-008, June 1991.

Case Studies in Wellhead Protection: Ten Examples of Innovative Wellhead Protection Programs, EPA 813-R-92-002, December 1992.

Seminar Publication--Wellhead Protection: A Guide for Small Communities, EPA 625/R-93/002, February 1993.

Drinking Water: Stronger Efforts Needed to Protect Areas Around Public Wells from Contamination, GAO/RC ED-93-96, April 14, 1993.

Handbook--Ground Water and Wellhead Protection, EPA 625/R-94/001, September 1994.

Final Wellhead Protection Requirements and the Status of Army Facilities, Prepared for U.S. Army Environmental Center, Prepared by Horne Engineering Services, Alexandria, Virginia, Contract No. DAAA15-94-D-0013, Task 3, April 17, 1995.

USACHPPM Technical Guide No. 179: Guidance For Providing Safe Drinking Water at Army Installations, USACHPPM, November 20, 1995.

WELLHEAD PROTECTION AREA DELINEATION

Delineation of Wellhead Protection Areas in Fractured Rocks, EPA 570/9-91-009, June 1991.

Guidelines for the Delineation of Wellhead Protection Areas, EPA 440/6-87-010, June 1987.

POTENTIAL CONTAMINATION SOURCE MANAGEMENT

Review of Sources of Ground-Water Contamination From Light Industry, EPA 440/6-90-005, May 1990.

Managing Ground-Water Contamination Sources in Wellhead Protection Areas: A Priority Setting Approach, EPA 570/9-91-023, October 1991.

CONTINGENCY PLANNING

Guide to Ground-Water Supply Contingency Planning for Local and State Governments, EPA 440/6-90-003, May 1990.

AWWA Manual M19, Emergency Planning for Water Utility Management, 3rd ed., AWWA, Denver, Colorado, 1994.

APPENDIX B
WELLHEAD PROTECTION PROGRAM FACTSHEET

DEVELOPMENT OF A WELLHEAD PROTECTION PLAN

1. Contact your primacy state and get a copy of their WHP Program.

2. Characterize the installation's ground water and overlying soil in accordance with your primacy state's WHP Program.

3. Delineate a WHPA around your well(s) using an approved method listed in your primacy state's WHP Program.

4. Inventory all potential sources of contamination that lie within the WHPA.

5. Prioritize these potential sources of contamination based upon the risk that they present to the wellhead.

6. Develop a management plan that will eliminate or minimize the threat of the above listed sources of contaminants.

7. Develop a contingency plan identifying responsible parties, responses, and alternate water supplies in the event of wellhead contamination.

8. Develop a public communication and education program regarding WHP and ground-water contamination.

9. Submit a draft of the installation WHP plan to your primacy state for approval.

WHP - wellhead protection, WHPA - wellhead protection area

APPENDIX C
APPROVED STATE WELLHEAD PROTECTION PROGRAMS

February 1996

States and U.S. Territories
with EPA Approved Wellhead Protection Programs

Alabama
Arizona
Arkansas
Colorado
Connecticut
Delaware
Georgia
Guam
Hawaii
Illinois
Indiana
Kentucky
Louisiana
Maine
Maryland
Massachusetts
Michigan
Mississippi
Missouri
Montana
Nebraska
Nevada
New Hampshire
New Jersey
New Mexico
New York
North Carolina
North Dakota
Ohio
Oklahoma
Puerto Rico
Rhode Island
South Carolina
South Dakota
Tennessee
Texas
Utah
Vermont
Washington
West Virginia
Wisconsin

APPENDIX D
STATE GROUND-WATER PROTECTION CONTACTS

Alabama
Dept of Environmental Management
Ground Water Branch
1751 Federal Drive
Montgomery, AL 36130

Alaska
Dept of Environmental Conservation
P.O. Box O
Juneau, AK 99811-1800

American Samoa
EPA Office of the Governor
Pago Pago, American Samoa 96799

Arizona
Ground Water Hydrology Section
Dept of Environmental Quality
2005 N. Central Avenue
Phoenix, AZ 85004

Arkansas
Dept of Health
Division of Engineering
4815 West Markham Street
Little Rock, AR 72205-3867

Dept of Pollution Control and Ecology
P.O. Box 9583
Little Rock, AR 72219

California
State Water Resources Control Board
P.O. Box 100
Sacramento, CA 95801

Colorado
Ground Water and Standards Section
Dept of Health
4210 East 11th Avenue
Denver, CO 80220

Connecticut
Dept of Environmental Protection
Room 177, State Office Building
165 Capital Avenue
Hartford, CT 06106

Delaware
Division of Water Resources
Ground Water Management Section
Dept of Natural Resources &
Environmental Control
P.O. Box 1401
Dover, DE 19903

District of Columbia
Dept of Consumer & Regulatory Affairs
614 H Street, N.W.
Washington, D.C. 20001

Florida
Dept of Environmental Regulation
Bureau of Drinking Water &
Ground Water Resources
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Georgia
Dept of Natural Resources
Floyd Towers East, Suite 1252
205 Butler Street, S.E.
Atlanta, GA 30334

Guam
EPA
P.O. Box 2999
Agana, GU 96910

Hawaii
Dept of Health
Ground Water Protection Program
500 Alamoana Boulevard
5 Waterfront, Suite 250
Honolulu, HI 96813

Idaho
Water Quality Health
Division of Environmental Quality
Dept of Health and Welfare
450 West State Street
Boise, ID 83720

Illinois
EPA
2200 Churchill Road
Springfield, IL 62706

Indiana
Dept of Environmental Management
105 South Meridian
P.O. Box 6015
Indianapolis, IN 46206

Iowa
Surface & Ground Water Protection Bureau
Dept of Natural Resources
Wallace State Office Building
900 East Grand Street
Des Moines, IA 50319

Kansas
Dept of Health and Environment
Bureau of Water Protection
Landon State Office Building
9th Floor, 900 S.W. Jackson
Topeka, KS 66620

Kentucky
Division of Water
Natural Resources & Environmental
Protection Cabinet
18 Reilly Road
Frankfort, KY 40601

Louisiana
Dept of Environmental Quality
P.O. Box 44066
Baton Rouge, LA 70804

Maine
Dept of Human Services
State House Station 10
Augusta, ME 04333

Dept of Environmental Protection
State House #17
Augusta, ME 04333

Marshall Islands
EPA, Office of the President
Republic of Marshall Islands
Majuro, Marshall Islands 96960

Maryland
Dept of the Environment
Room 8L
2500 Broening Highway
Baltimore, MD 21224

Massachusetts
Division of Water Supply
Dept of Environmental Quality Engineering
1 Winter Street
Boston, MA 02108

Michigan
Dept of Public Health
P.O. Box 30035
Lansing, MI 48909

Office of Water Resources
Dept of Natural Resources
P.O. Box 30028
Lansing, MI 48909

Minnesota
Dept of Health
P.O. Box 59040
Minneapolis, MN 55459

Pollution Control Agency
520 Lafayette Road N, 6th Floor
St. Paul, MN 55155

Mississippi
Ground Water Quality Branch
Bureau of Pollution Control
P.O. Box 10385
Jackson, MS 39289-0385

Missouri
Dept of Natural Resources
P.O. Box 176
Jefferson, MO 65102

Montana
Water Quality Bureau
Dept of Health & Environmental Sciences
Cogswell Building, Room A206
Helena, MT 59620

Nebraska
Division of Environmental Control
State House Station
P.O. Box 98922
Lincoln, NE 68509-4877

Nevada
Division of Environmental Protection
201 South Fall St., Room 221
Carson City, NV 89710

New Hampshire
Ground Water Protection Bureau
Dept of Environmental Services
6 Hazen Drive
Concord, NH 03301

New Jersey
Division of Water Resources
Dept of Environmental Protection
CN029
Trenton, NJ 08625-0029

New Mexico
Environmental Improvement Division
1190 St. Francis Drive
Santa Fe, NM 87504

New York
Bureau of Water Quality Management
Dept of Environmental Conservation
50 Wolf Road
Albany, NY 12233-3500

North Carolina
Ground Water Section
Dept of Environmental, Health & Natural Resources
P.O. Box 27687
Raleigh, NC 27611

North Dakota
Division of Water Supply & Pollution Control
Dept of Health
P.O. Box 5520
Bismark, ND 58502-5520

Northern Mariana Islands
Division of Environmental Quality
P.O. Box 1304
Saipan, Mariana 96950

Ohio
Division of Ground Water
Ohio EPA
Box 1049
Columbus, OH 43266-0149

Oklahoma
Dept of Pollution Control
P.O. Box 53504
Oklahoma City, OK 73152

Oregon
Dept of Environmental Quality
811 SW 6th Avenue
Portland, OR 97204-1334

Pennsylvania
Office of Environmental Management
Dept of Environmental Resources
P.O. Box 2063
Harrisburg, PA 17120

Division of Water Supplies
Dept of Environmental Resources
P.O. Box 2357
Harrisburg, PA 17120

Puerto Rico
Water Quality Area
Environmental Quality Board
Box 11488
Santurce, PR 00910

Rhode Island
Dept of Environmental Management
9 Hayes Street
Providence, RI 02903

South Carolina
Bureau of Water Supply & Special Programs
Dept of Health & Environmental Control
2600 Bull Street
Columbia, SC 29201

South Dakota
Division of Environmental Regulation
Dept of Water & Natural Resources
Joe Foss Building
Pierre, SD 57501-3181

Tennessee
Dept of Health and Environment
Division of Water Supply
150 Ninth Avenue, North
Nashville, TN 37219-5404

Texas
Texas Dept of Health
1100 Wst 49th Street
Austin, TX 78756

Texas Water Commission
P.O. Box 13087
Austin, TX 78711-3087

Utah
Bureau of Drinking Water & Sanitation
Division of Environmental Health
288 North 1460 West
Salt Lake City, UT 84116-0690

Bureau of Water Pollution Control
Division of Environmental Health
288 North 1460 West
Salt Lake City, UT 84114-0700

Vermont
Division of Environmental Health
Dept of Health
60 Main Street
Burlington, VT 05401

Agency of Natural Resources
1 South Building
103 Main Street
Waterbury, VT 05676

Virginia
Water Control Board
P.O. Box 11143
Richmond, VA 23230-1143

Virgin Islands
Dept of Planning & Natural Resources
179 Altona & Welgunst
St. Thomas, VI 00820

Washington
Dept of Social and Health Services
Olympia, WA 98504

Dept of Ecology
Mail Stop PV 11
Olympia, WA 98504

West Virginia
Office of Environmental Health Services
1800 Washington Street, East
Charleston, WV 25305

Dept of Natural Resources
1800 Washington Street, East
Charleston, WV 25305

Wisconsin
Division of Environmental Standards
Dept of Natural Resources
P.O. Box 7921
Madison, WI 53707

Wyoming
Dept of Environmental Quality
Water Quality Division
Herschler Building, 4th Floor
122 West 25th
Cheyenne, WY 82002

GLOSSARY

SECTION 1 - ABBREVIATIONS

EPA	U.S. Environmental Protection Agency
GIS	Geographical Information System
MEDCEN	Medical Center (larger medical facility, regionally located)
MEDDAC	Medical Department Activity (smaller, at many large installations)
MOU	Memorandum of Understanding
NPDES	National Pollutant Discharge Elimination System
NSF	National Sanitation Foundation
POE	Point-of-Entry
POU	Point-of-Use
PWS	Public Water Supply
RCRA	Resource Conservation and Recovery Act
ROWPU	Reverse Osmosis Water Purification Unit
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SPCC	Spill Prevention Control and Countermeasure
TG	Technical Guide
TOT	Time of Travel
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USAEC	U.S. Army Environmental Center
USAEHA	U.S. Army Environmental Hygiene Agency (now USACHPPM)
WHP	Wellhead Protection
WHPA	Wellhead Protection Area
ZOC	Zone of Contribution
ZOI	Zone of Influence

SECTION 2 - TERMS

1. Aquifer - A formation, group of formations, or part of a formation that contains sufficient water-saturated permeable material to yield economical quantities of water to wells and springs.

2. Conductivity - A coefficient, (K), of proportionality describing the rate at which water can move through a permeable medium.

3. Cone of Depression - A depression in the water table or potentiometric surface that has the shape of an inverted cone and develops around a well as it is pumped. Its cross-section defines the zone of influence around a well.

4. Contaminant - An undesirable substance not normally present, or an unusually high concentration of a naturally occurring substance, in water, soil, or other environmental medium.

5. Contaminant Plume - An elongated and mobile column or band of a pollutant moving through the subsurface.

6. Drawdown - The vertical distance ground-water elevation is lowered, or the amount head is reduced, due to the removal (pumping) of ground water.

7. Ground Water - Water in the saturated zone that is under pressure equal to or greater than atmospheric pressure.

8. Ground-Water Divide - A ridge in the water table or potentiometric surface from which ground water moves away at right angles in both directions.

9. Hydraulic Conductivity - A proportionality constant relating hydraulic gradient to specific discharge. The rate of flow of water in gallons per day through a cross-section of one square foot of medium under a unit hydraulic gradient (gpd/ft^2).

10. Hydraulic Gradient - The rate of change in total head per unit of distance of flow in a given direction.

11. Isotropic - The condition in which the hydraulic properties of interest of the aquifer are the same in all directions.

12. Lithologic - Relating to rock, unconsolidated material, or soil.

13. Permeable - Having a texture that permits water to move through it under the head difference ordinarily found in ground water.

14. Porosity - the percentage of the bulk volume of a rock or soil that is occupied by interstices, whether isolated or connected.

15. Potentiometric Surface - An imaginary surface representing the total head of ground water in a confined aquifer that is defined by the level to which water will rise in a well.

16. Primacy State - Agent with authority and jurisdiction to dictate drinking water criteria and standards to public water systems. The State has primacy in most cases, otherwise EPA has primacy authority.

17. Recharge Area - Area in which water reaches the ground-water reservoir by surface infiltration. An area in which there is a downward component of hydraulic head in the aquifer.

18. Storativity - The amount of water an aquifer will release from storage.

19. Time of Travel - The amount of time it takes for water and contaminants to reach a well from a certain distance.

20. Transmissivity - The capacity of an aquifer to transmit water; equal to the hydraulic conductivity times the aquifer thickness.

21. Vadose Zone - The zone of soil or ground material between the land surface and the water table. It includes the root zone, intermediate zone, and capillary fringe. The pore spaces contain water as well as air and other gases at less than atmospheric pressure. (Sometimes called the unsaturated zone.)

22. Water Table - The surface between the vadose zone and the ground water; that surface of a body of unconfined ground water at which the pressure is equal to that of the atmosphere.

23. Wellhead - The physical structure, facility, or device at the land surface from or through which ground water flows or is pumped from subsurface, water-bearing formations.

24. Wellhead Protection Area - As used in this document, the term Wellhead Protection Area (WHPA) means the surface and subsurface area surrounding a water well or well field, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or well field

25. <u>Zone of Contribution (ZOC)</u> - The area surrounding a pumping well that encompasses all of the surface and subsurface area that supplies ground-water recharge to the well.

26. <u>Zone of Influence (ZOI)</u> - The area surrounding a pumping well within which the water table or potentiometric surfaces have been changed due to ground-water withdrawal.

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